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Development of Quantitative Magnetic Resonance Imaging (qMRI) Methods for Radiotherapy Response Studies

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Aims: We have initiated a PhD project to investigate and implement improvements of diffusion-weighted quantitative magnetic resonance imaging (DW-qMRI) and supplementary measures as biomarkers for RT response in human brain metastases. A further aim is to propose dedicated MRI sequences for radiotherapy (RT), enabling simultaneous real-time target monitoring.

Background: Tumors are inhomogeneous structures and may often be divided into subregions based on cell density, perfusion, edema, hypoxia, etc. Radiation induces cellular reactions and sub-region changes during the course of RT. Thus, there is potential for finding biomarkers for microstructural changes at a cellular level to evaluate cancer treatment response earlier than anatomical changes. In a recent study, DW-MRI has been demonstrated in a clinical trial as an early biomarker of treatment response in brain metastases (Mahmood et al. 2017). However, viable-tumor summary statistics were used for evaluation, and a voxel-wise approach still needs to be implemented to determine local response. Additionally, sensitivity to region-of-interest definition and choice of estimation method (Mahmood et al. 2015) calls for an optimization of qMRI sequences and post-processing approaches before clinical feasibility testing. The growing role of MRI in target definition and potentially in treatment adaptation has recently resulted in commercialization of hybrid MRI – linear accelerator systems. This potentially enables daily adaptation of treatment plans based on biological information acquired with qMRI.

Methods: Existing clinical trial data will be used for development of voxel-based analyses of the metastases based on multi-parametric classification/clustering methods. Multi-parametric qMRI optimization will be pursued using simulation and sequence development tools. In particular, highly sensitive fast mapping of diffusion and relaxation parameters will be developed. Among the issues to address when sensitivity is optimized are partial volume effects, hardware imperfections, suppression of unwanted signals, and motion. Testing in phantoms and healthy volunteers is planned before patient pilot scans.

Perspective: The study is expected to produce general prognostic and monitoring methods for patients with brain metastases, and potentially also other tumor sites. If individualized treatment improves local control and symptom management while not increasing side effects, quality of life will increase for these patients. Net treatment costs may also be reduced.

References:

Mahmood et al, Physics in Medicine & Biology, 2017, 62, 2990-3002
Mahmood et al, Acta Oncologica, 2015, Early Online, 1-6.